Indications for Interventional Radiology in the Management of Patients with Spinal Cord Injuries

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Objectives: To outline a range of minimally invasive image-guided procedures that benefit spinal cord–injured patients and may expedite clinical care. **Study design:** Pictorial review. **Results/Conclusions:** Image-guided procedures have made a significant impact in medical management in many specialties. These techniques continue to evolve rapidly and afford opportunities to reduce patient morbidity and in-patient length of stay. **Key words:** *interventional radiology, pressure ulcers, renal tract, spinal injuries*

Image-guided procedures have made a significant impact in medical management in many specialties, including spinal injury. Techniques continue to evolve rapidly and provide opportunities to reduce patient morbidity and in-patient length of stay. We briefly outline a range of minimally invasive image-guided procedures that benefit patients with spinal cord injury (SCI) and that may expedite clinical care.

Image-Guided Botulinum Toxin Injections

Although diffuse spasticity is most appropriately treated with regional (eg, intrathecal baclofen) or systemic therapies, patients with spasticity of a certain muscle group can be effectively treated with botulinum neurotoxin A (BTA).[1,2] In patients with paraplegia, spasticity of the psoas muscle can be a great source of complaint often resulting in functional disability. In patients with tetraplegia, shoulder pain is a common problem due to spasticity in the subscapularis muscle. These 2 muscle groups (psoas and subscapularis) are deeply situated and their accurate localization is essential for maximal efficacy of BTA injection. Computed tomography (CT) guidance is the most accurate procedure for the precise and rapid injection of BTA into both psoas and subscapularis muscles (**Figure 1**). With more modern scanners, radiation doses are lower particularly when CT fluoroscopy is used. Other common guidance modalities for the injection of BTA include ultrasound and electromyography.

Endovascular Techniques for Pressure Sores

Pressure ulcers are a well-recognized complication in patients with SCI, with a prevalence of 30% to 50% in chronic SCI patients.[3] Arterial insufficiency may be a significant factor that might impede graft success if surgery is undertaken for the treatment of a pressure sore. Preliminary imaging to evaluate the vascular supply may be performed with arterial Duplex sonography, magnetic resonance angiography, or CT angiography (**Figure 2**).

If a diagnosis of arterial insufficiency is established, the patient should be considered a candidate for treatment with angioplasty. Angioplasty as a preoperative procedure may increase the chances of graft success; it can

Top Spinal Cord Inj Rehabil 2013;19(3):211–221

www.scijournal.com

doi: 10.1310/sci1903-211

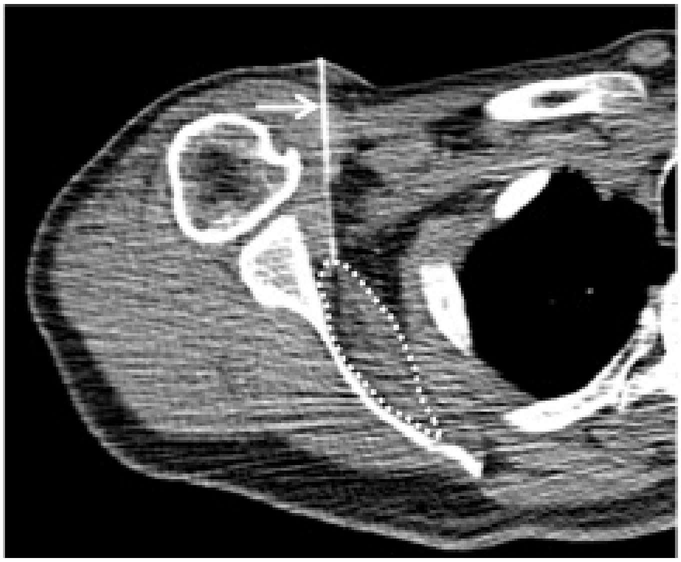

Figure 1. Computed tomography (CT) image-guided botulinum injection highlighting a case of a male tetraplegic patient who was experiencing disabling spasms in his upper limb. Axial CT image of the patient lying supine. A 25-gauge needle (*white arrow*) was placed into the subscapularis muscle (*dashed lines*) via an anterior approach. The patient's spasms subsided for 3 months following the injection.

also be used as a definitive treatment in itself. Another contributor to nonhealing pressure sores is osteomyelitis, which can be improved by angioplasty. Improving the blood supply to the region will boost the delivery of antimicrobial therapy.

Spinal Intervention: Diagnostic

CT myelography

A number of patients will be unable to undergo magnetic resonance imaging (MRI) due to implants such as permanent pacemakers, cord stimulators, baclofen pumps, or deformity (eg, severe kyphosis). CT myelography can provide useful information by demonstrating the spinal canal and its contents in great detail (Figures **3A** and **3B**).[4] The procedure involves the introduction of contrast using the same technique as myelography. CT scanning can be undertaken immediately following the myelogram. If syrinx is suspected, delayed scans are necessary typically at 4 hours. This will demonstrate most syrinx cavities, although delayed scans at 24 hours may be necessary.

Vertebral and disc biopsy

Patients with SCI may present with cord injury secondary to vertebral or disc infection. In this situation, surgical decompression will be performed and samples will be taken for culture and microscopy.

A number of patients in the subacute or chronic phase of cord injury being investigated for back pain or fever will demonstrate MRI signs suspicious for osteomyelitis or discitis.

Image-guided biopsy using either CT or fluoroscopic guidance (**Figure 3C**) can be used to obtain samples for culture, microscopy, and histology.

It is particularly important that specimens be sent for both histology and microbiology, as in some cases the microbiology may be negative and histology can guide a likely diagnosis.

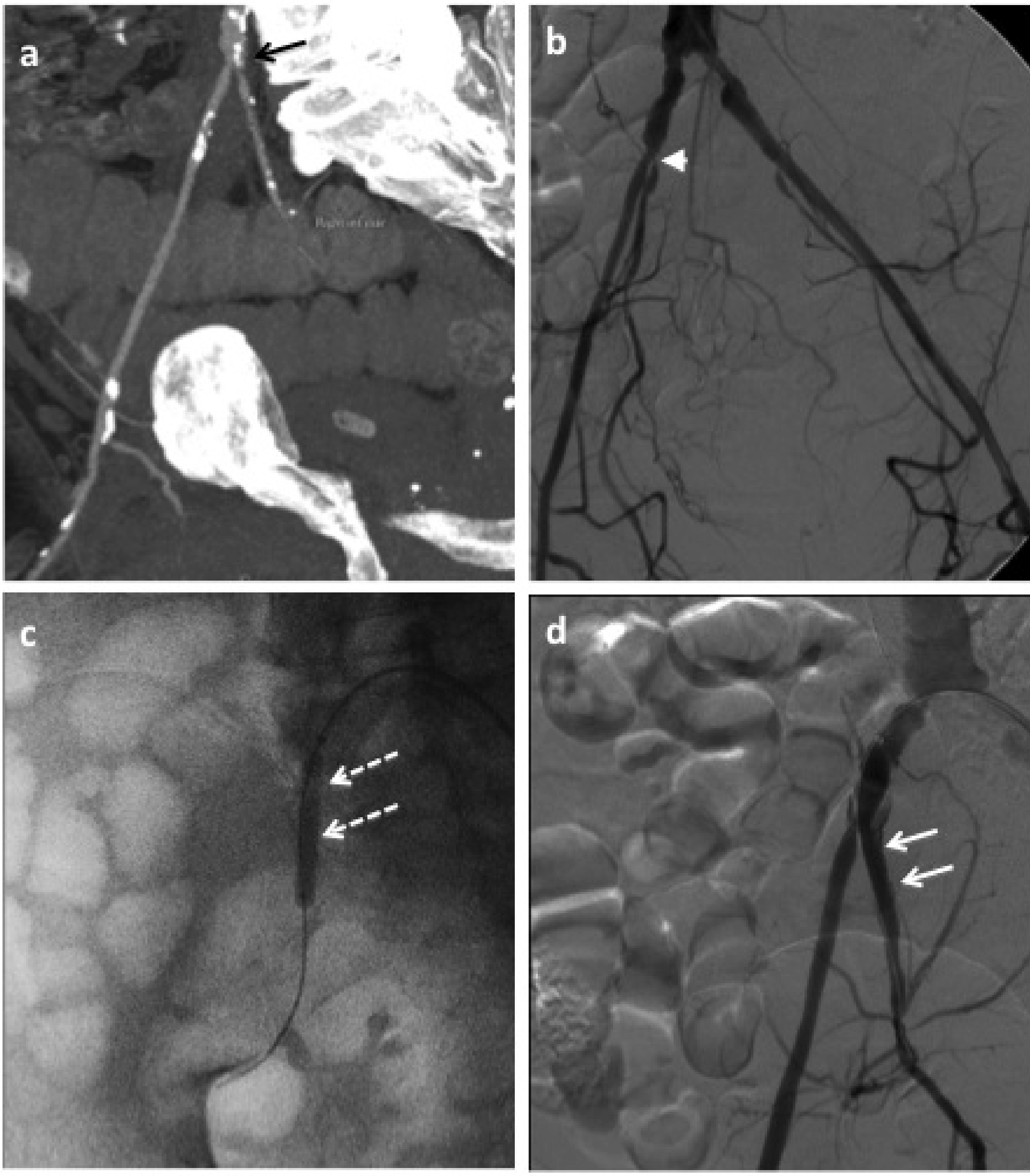

Figure 2. Endovascular techniques for pressure sores in a 54-year-old man with a longstanding SCI and a nonhealing ischial pressure ulcer. (a) Coronal oblique maximum intensity projection (MIP) CT image shows calcified plaque (*black arrow*). (b) Diagnostic subtraction angiogram performed via a right common femoral artery puncture confirms stenosis at the origins of both internal iliac arteries (*white arrowhead*). (c) Balloon inflation is shown across right internal iliac artery stenosis (*white dashed arrows*). (d) Diagnostic substraction angiogram post balloon inflation shows improvement of internal iliac artery lumen (*white arrows*). There was good angiographic result post stenosis dilation.

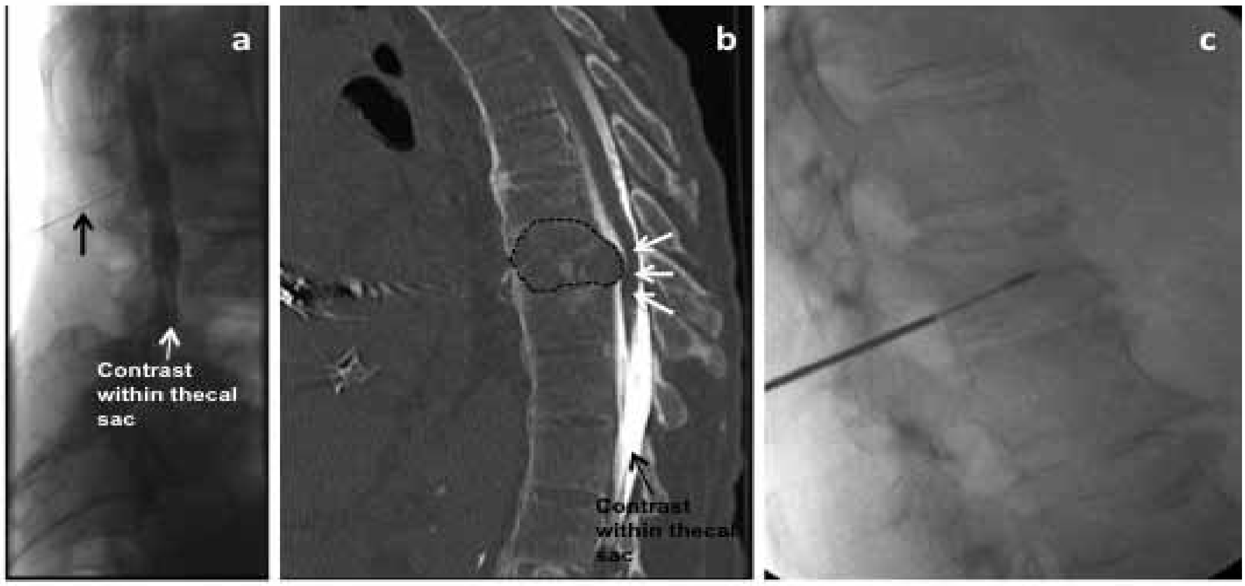

Figure 3. CT myelography and vertebral biopsy. (a) Lateral fluoroscopic image shows contrast injected into thecal sac using 22-gauge spinal needle (*black arrow*) at the L1/2 level. (b) CT lateral image post intrathecal contrast injection shows posterior displacement of the conus (*white arrows*) by a discitis related abscess (*black dashed lines*). (c) Biopsy needle was advanced into vertebral body under fluoroscopic guidance, ensuring a diagnostic sample is obtained safely.

Spinal Intervention: Therapeutic

Back pain is a common problem in people with SCI. The reported prevalence averages 65%, with around one-third of these people rating their pain as severe.[5] In most cases, pain is neurogenic in origin, but a number of persons will have mechanical pain relating to disc or facet joint disease. If clinical suspicion allied to MRI findings of nerve root compression or facet joint disease suggests these as a source of pain, CT-guided injection is an accurate method of treatment (**Figure 4**). Usually a combination of long-acting steroids (eg, triamcinolone acetonate 40 mg) and 1 mL of 0.5% bupivicaine can provide both a diagnostic and therapeutic benefit.[6,7]

CT may also be used for epidural injections and may have some advantage over fluoroscopy in avoiding injection into the dura if there is significant arachnoiditis.

Spinal Intervention: Vertebroplasty

There has been increasing interest in the use of vertebral cement augmentation techniques (vertebroplasty, kyphoplasty) in spinal trauma. These techniques were originally described in the mid 1980s[8] and have been predominantly utilized in the treatment of painful osteoporotic or myelomatous compression fractures.

More recently, several authors have described cement augmentation either alone or in combination with pedicle screw fixation for traumatic thoracolumbar burst injuries.[9-11] This technique has the potential advantage of providing anterior column support with cement and posterior stabilization without the need for anterior surgical approach (**Figure 5**). This technique has been shown to be effective by a recent study.[12]

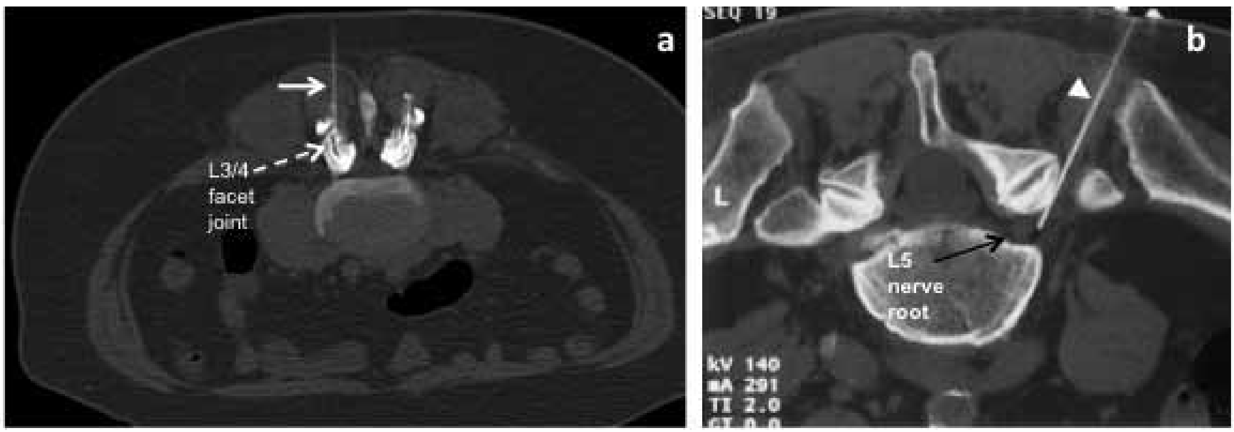

Figure 4. Therapeutic interventions. (a) CT axial image of prone patient shows peri-articular injection using 22-gauge spinal needle (*arrow*) into degenerative right L3/4 facet joint (*dashed arrow*). (b) CT-guided needle placement (*arrowhead*) lies adjacent to the right L5 nerve root sleeve (*black arrow*).

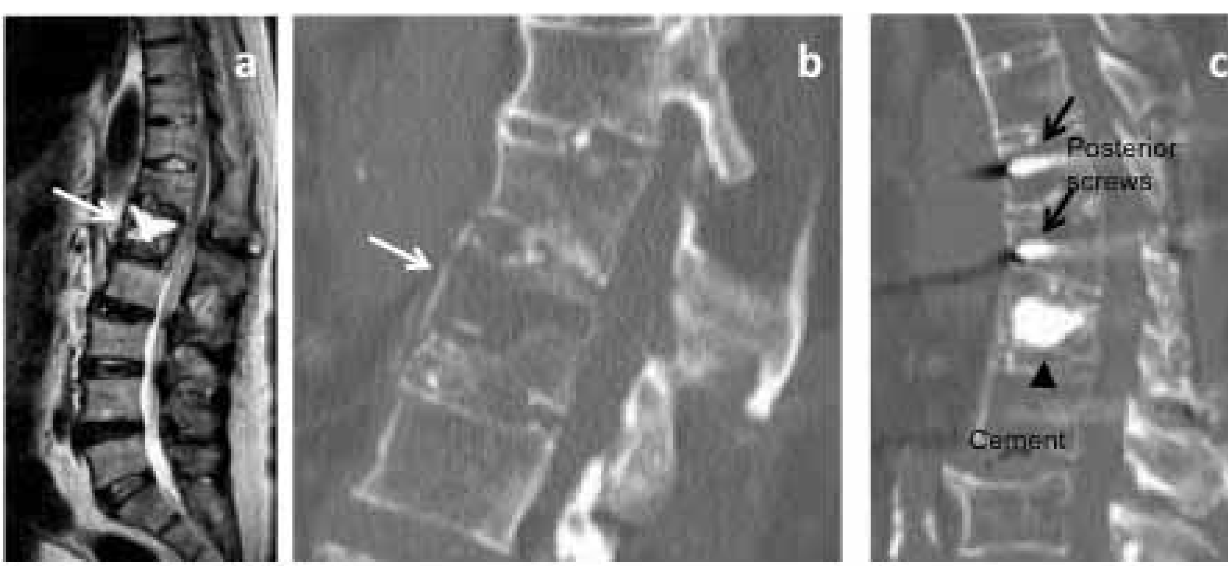

Figure 5. Vertebroplasty. A 60-year-old patient presented with pain and spasm and a cervical spinal injury with pseudarthrosis (*white arrows*) at T12/L1 that was demonstrated on (a) sagittal T2-weighted MRI and (b) CT scan. (c) Sagittal CT post anterior cement augmentation (*black arrowhead*) and posterior screw stabilization (*black arrows*) are shown.

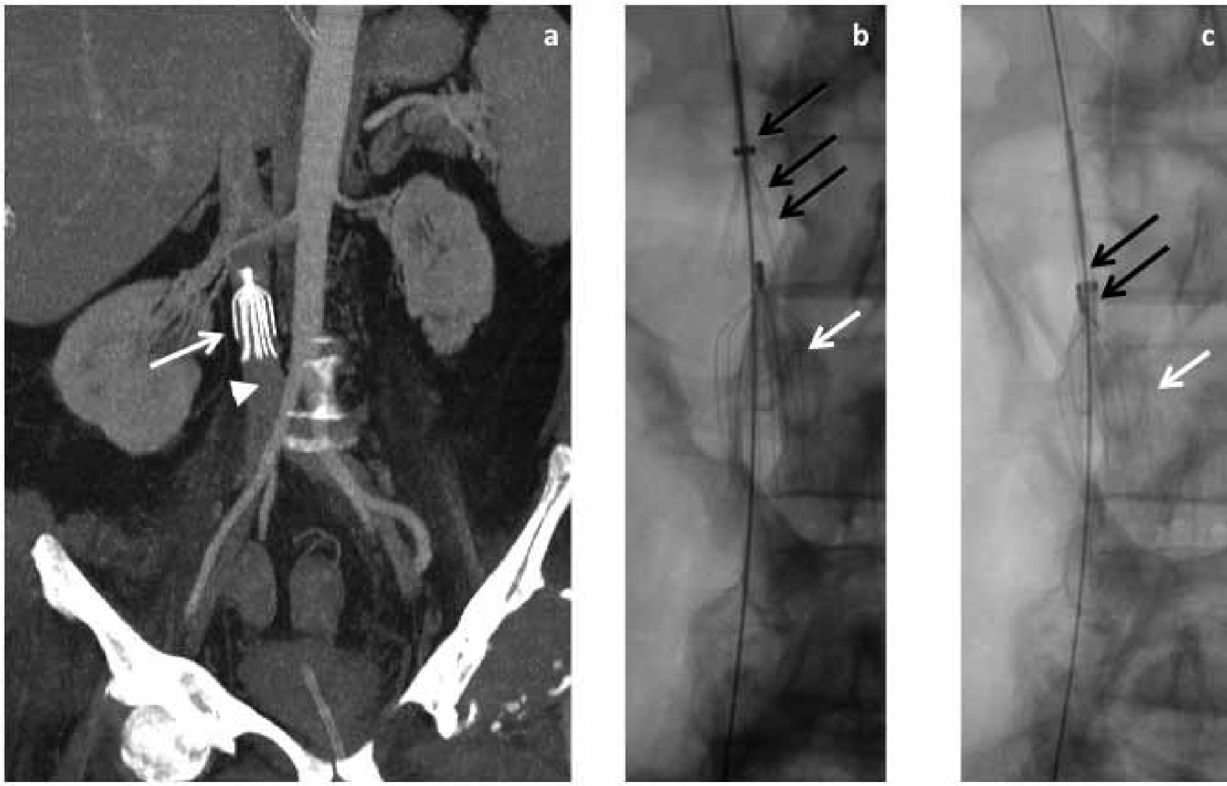

Figure 6. Inferior vena cava (IVC) filter placement and removal in a 45-year-old SCI patient with bleeding pressure sore and history of deep vein thrombosis. IVC filter was placed allowing anticoagulation to be stopped safely. (a) Coronal oblique maximum intensity projection (MIP) CT image shows the filter (*white arrow*) in the IVC (*arrowhead*). Once the pressure sore had improved and was no longer bleeding, anticoagulation could be commenced and the filter retrieved. (b) Fluoroscopic images of an IVC filter retrieval device (*black arrows*) being introduced into the IVC via the internal jugular vein. (c) The device then closes over the filter (*white arrow*) in order to remove it.

Interventions for Venous Thromboembolism

Venous thromboembolism (VTE) is common in patients with SCI. Pulmonary embolism has been reported to occur in approximately 5% of patients with SCI and remains the third leading cause of death in this population in the first year after injury.[13]

Interventional techniques include thrombolysis for acute severe embolism with signs of right heart strain or reduced cardiac output. A catheter is placed into the pulmonary artery and a thrombolytic agent is directly infused. It may also be possible to mechanically extract fragments of thrombus.

For patients with recurrent emboli who are receiving treatment or who have contraindications to anticoagulation, inferior vena cava (IVC) filters may be indicated (**Figure 6A**).[14] The use of retrievable IVC filters has dramatically increased in recent years: The patients are protected during the high-risk period post SCI, and the IVC filter is removed at a later date when the risk of thromboembolism or anticoagulation has diminished (**Figure 6B** and **6C**).[15]

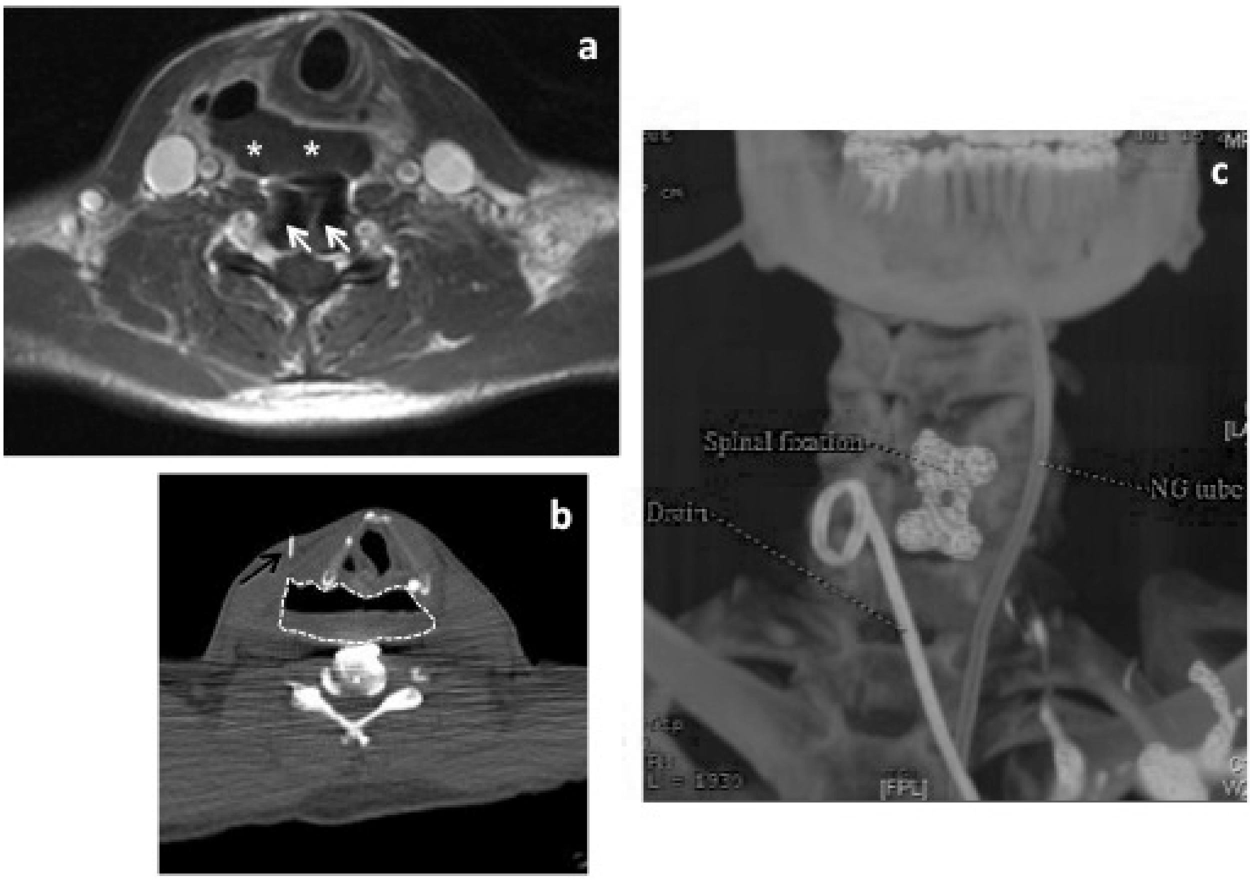

Figure 7. Image-guided drainage. (a) Axial T1-weighted MRI demonstrates a pre-vertebral infected collection (*white asterisks*) anterior to the level where metal instrumentation is present (*white arrows*). (b) Axial CT image shows introduction of needle (*black arrow*) from a right anterior approach into the infected, gas-containing collection (*dashed outline*). A drain was then inserted into the collection using a Seldinger technique. (c) Coronal maximum intensity projection (MIP) CT image demonstrates the drain in situ.

Image-Guided Drainage

Image-guided drainage has become a standard procedure for many clinical situations in patients with SCI. Pleural effusion drainage is one of the more common indications, but any collection is usually amenable to either ultrasound or CT-guided drainage.

More recent considerations are the development of tunneled chest drains for chronic effusions. **Figure 7** shows a drain placed for an infected cervical prevertebral collection related to discitis.

Gastrostomy

Gastrostomy is a well-established technique in patients deemed to have an unsafe swallow and risk of aspiration. There are 2 techniques for gastrostomy placement: endoscopic by placement of a percutaneous endoscopic gastrostomy (PEG) or fluoroscopic gastrostomy. The image-guided technique uses only small-bore nasogastric tubes for gastric insufflations (**Figure 8**). Rates of site infection for the endoscopic technique range from 8.8% to 20%,[16] whereas fluoroscopic gastrostomy tube placement infection rates are reported to be in the range of 2%.[17]

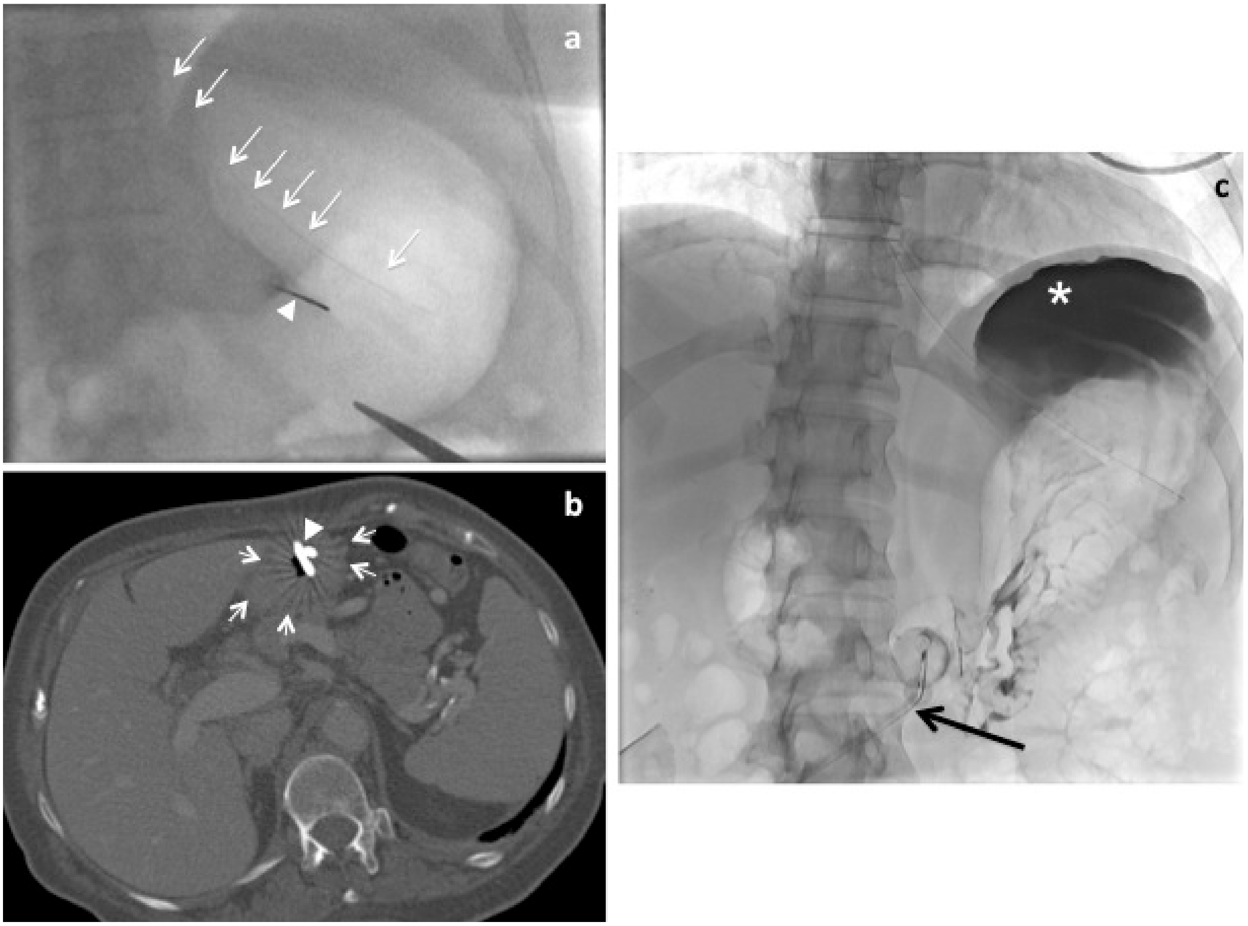

Figure 8. Gastrostomy. (a) Fluoroscopic image of stomach insufflated with gas via an nasogastric tube (*white arrows*), displacing adjacent bowel loops and facilitating visualization of the stomach to allow safe puncture with a needle (*arrowhead*). (b) Axial CT image shows correct placement of gastrostomy tube (*arrowhead*) within the stomach (outlined by *white thin arrows*). (c) Fluoroscopic image of stomach following gastrostomy (*black arrow*) placement. Radio-opaque contrast is injected through the gastrostomy to ensure no intraperitoneal leak occurs. Contrast material in stomach is demonstrated by a *white asterisk*.

Long-Term Venous Access

Peripherally-inserted (long-term) central venous catheters (PICC) are used for the administration of antibiotics, chemotherapeutic drugs, and total parenteral nutrition and for providing high-flow access for hemodialysis and plasmapheresis. Indwelling catheters also offer the ability to obtain frequent blood samples, which eliminates the need for repeated percutaneous punctures that are not only undesirable for patients, but can result in stenosis or occlusion of the targeted vessels.

A combination of ultrasound and fluoroscopy is commonly used for image guidance in the placement of central venous access devices (**Figure 9**). Ultrasound guidance allows dynamic scanning during needle placement ensuring intravenous (rather than, for example, intra-arterial) location, which is particularly important in those patients with coagulopathy. Once intravenous needle placement is secured, fluoroscopy is used to follow the route taken by the guide wire, ensuring its path is inferior toward superior vena cava/right atrium.

Figure 9. Ultrasound-guided placement of long-term central venous catheter. Photograph and ultrasound image show position of probe placement for visualization of the internal jugular vein (*long dotted dashed area*) and carotid artery (*round dotted dashed area*), ensuring safe catheter placement.

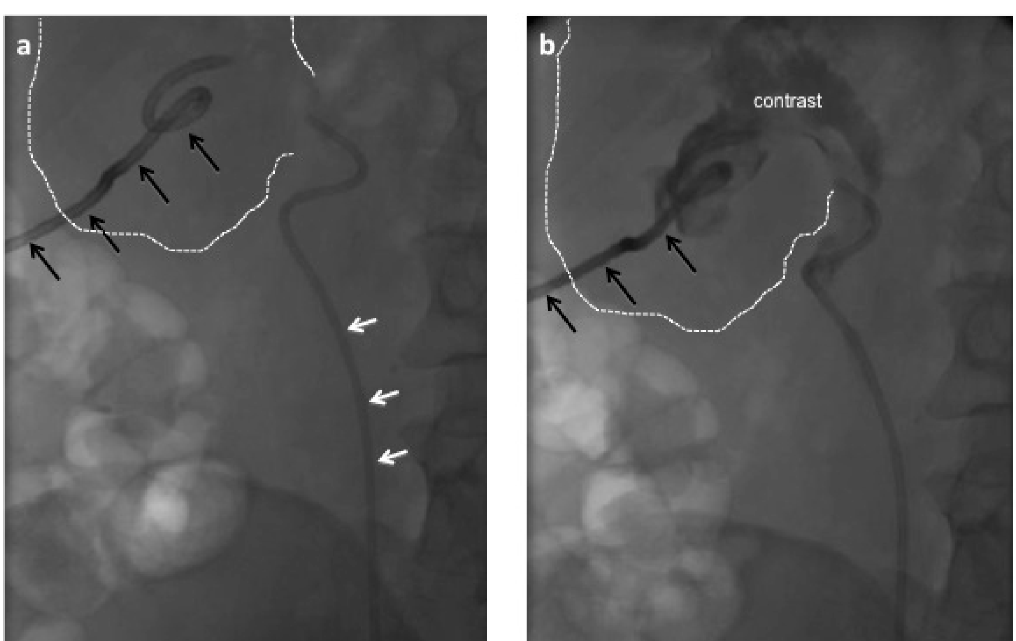

Figure 10. Nephrostomy. (a) Fluoroscopic image demonstrates a nephrostomy (*black arrows*) with pigtail catheter in the lower pole calyx of the kidney (*white dashed outline*). There is also a ureteric stent in situ (*white arrows*). (b) Fluoroscopic image taken following the injection of contrast through the nephrostomy (*black arrows*), outlining the pelvicalyceal system.

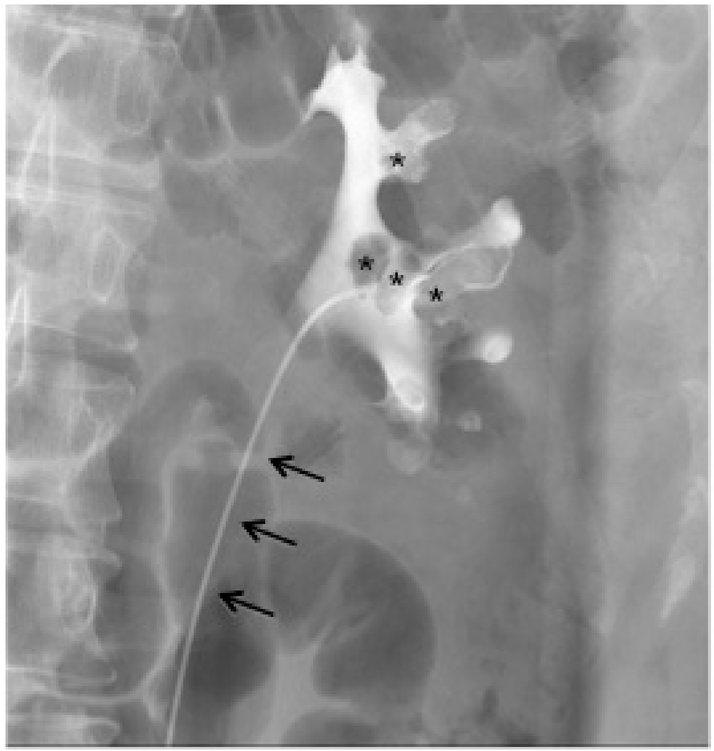

Figure 11. Percutaneous nephrolithotomy (PCNL). X-ray following contrast injection through ureteric stent (*black arrows*) outlines pelvicalyceal system. Several filling defects (*asterisks*) within the renal pelvis are demonstrated due to large stone burden. This patient was later treated with PCNL.

Urological Intervention

Urologic complications are an important cause of morbidity and mortality in patients with SCI. The common pathologies requiring image-guided intervention are obstructed hydronephrosis and renal stone disease.

Percutaneous nephrostomy

Acute sepsis with infected hydronephrosis constitutes a medical emergency. To prevent multi-organ failure from overwhelming sepsis and to preserve renal function in the affected kidney, urgent decompression by nephrostomy or J stent insertion is necessary (**Figure 10**).[18]

The nephrostomy can also be a useful access point for other more definitive procedures: It can be used to assist retrograde access by ureteroscopy thus allowing placement of a ureteric stent, and it can serve as the percutaneous access for subsequent stone removal by percutaneous nephrolithotomy (PCNL).

Percutaneous nephrolithotomy

Extracorporeal shockwave lithotripsy (ESWL) is the treatment of choice for small (<2 cm) upper and middle pole renal stones, but PCNL remains the most effective approach for larger stones (**Figure 11**) or for those within the lower pole.

This procedure involves general anesthetics, and the introduction of a rigid nephroscope through a posterior approach. Once the stone is visualized, the stone mass is disintegrated using ultrasonic fragmentation. Stone fragments are retrieved with graspers. Post procedure, a large bore nephrostomy (20-26F) and/ or a ureteric stent is left in situ (most renal stones in spinal-injured patients are infective in origin so tubeless PCNL is not appropriate). A nephrostogram is performed 24 to 72 hours following the procedure for assessment of ureteric drainage and to determine whether it is safe to remove the nephrostomy.

Acknowledgments

The authors report no conflicts of interest.

REFERENCES

1. Hesse S, Mauritz KH. Management of spasticity. *Curr Opin Neurol.* 1997;10(6):498-501.
2. Garreta-Figuera R, Chaler-Vilaseca J, Torrequebrada-Gimenez A. Clinical practice guidelines for the treatment of spasticity with botulinum toxin. *Rev Neurol.* 2010;50(11):685-699.
3. Chen Y, Devivo MJ, Jackson AB. Pressure ulcer prevalence in people with spinal cord injury: Age-period-duration effects. *Arch Phys Med Rehabil.* 2005;86(6):1208-1213.
4. Bodley R. Imaging in chronic spinal cord injury – indications and benefits. *Eur J Radiol.* 2002;42(2):135-153.
5. Siddall PJ, Loeser JD. Pain following spinal cord injury. *Spinal Cord.* 2001;39(2):63-73.
6. Teh J, Imam A, Watts C. Imaging of back pain. *Imaging.* 2005;17(3):171-207.
7. Teh J, Ostlere S. Percutaneous spinal procedures. *Imaging.* 2005;17(3):258-267.
8. Galibert P, Deramond H, Rosat P, Le Gars D. [Preliminary note on the treatment of vertebral angioma by percutaneous acrylic vertebroplasty]. *Neurochirurgie.* 1987;33(2):166-168.
9. Ni WF, Huang YX, Chi YL, et al. Percutaneous pedicle screw fixation for neurologic intact thoracolumbar burst fractures. *J Spinal Disord Tech.* 2010;23(8):530-537.
10. Fuentes S, Blondel B, Metellus P, Gaudart J, Adetchessi T, Dufour H. Percutaneous kyphoplasty and pedicle screw fixation for the management of thoraco-lumbar burst fractures. *Eur Spine J.* 2010;19(8):1281-1287.
11. Marco RA, Meyer BC, Kushwaha VP. Thoracolumbar burst fractures treated with posterior decompression and pedicle screw instrumentation supplemented with balloon-assisted vertebroplasty and calcium phosphate reconstruction. Surgical technique. *J Bone Joint Surg Am.* 2010;92(Suppl 1, Pt 1):67-76.
12. Uchida K, Nakajima H, Yayama T, et al. Vertebroplasty-augmented short-segment posterior fixation of osteoporotic vertebral collapse with neurological deficit in the thoracolumbar spine: Comparisons with posterior surgery without vertebroplasty and anterior surgery. *J Neurosurg Spine.* 2010;13(5):612-621.
13. Kirshblum S. Rehabilitation of spinal cord injury. In: DeLisa JA, Gans BM, Walsh NE, eds. *Physical Medicine and Rehabilitation: Principles and Practice.* Vol 2. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2005:1715-1752.
14. National Guideline C. Prevention of thromboembolism in spinal cord injury. http://www.guideline.gov. Accessed October 24, 2011.
15. Johns JS, Nguyen C, Sing RF. Vena cava filters in spinal cord injuries: Evolving technology. *J Spinal Cord Med.* 2006;29(3):183-190.
16. Shike M, Berner YN, Gerdes H, et al. Percutaneous endoscopic gastrostomy and jejunostomy for long-term feeding in patients with cancer of the head and neck. *Otolaryngol Head Neck Surg.* 1989;101(5):549-554.
17. Beaver ME, Myers JN, Griffenberg L, Waugh K. Percutaneous fluoroscopic gastrostomy tube placement in patients with head and neck cancer. *Arch Otolaryngol Head Neck Surg.* 1998;124(10):1141-1144.
18. Lee WJ, Mond DJ, Patel M, Pillari GP. Emergency percutaneous nephrostomy: Technical success based on level of operator experience. *J Vasc Interv Radiol.* 1994;5(2):327-330.